SOIL SURVEY OF THE BAKER CITY AREA, OREGON.

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LOCATION AND BOUNDARIES OF THE AREA.

Baker County is located on the eastern border of the State, a little north of the center. The area surveyed begins at Baker City, practically the center of the county, and extends north a distance of about 22 miles. The northern limit, which extends from 2 to 4 miles into Union County, follows the line of foothills from a fraction of a mile

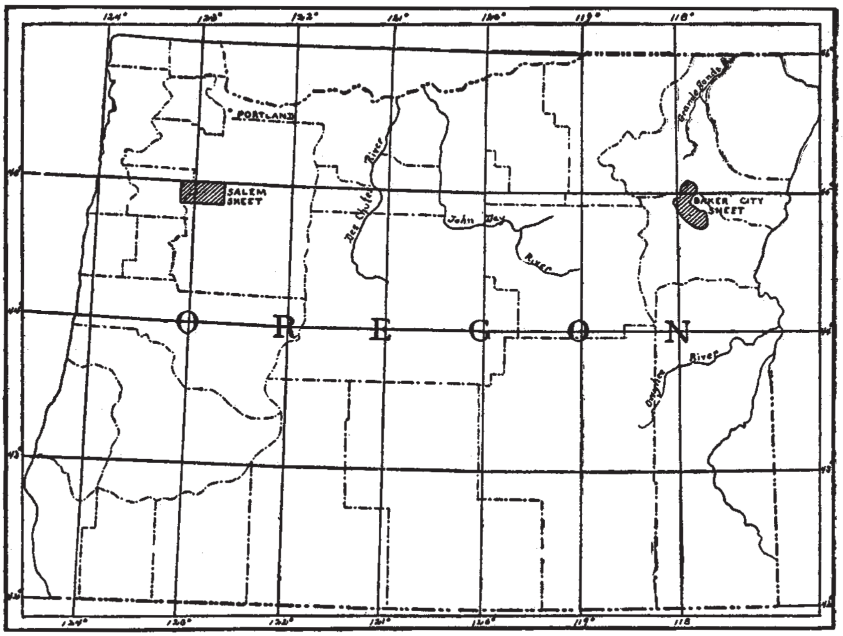

FIG. 56.—Sketch map showing location of the Baker City area, Oregon.

to about 1½ miles north of Wolf Creek. The area is entirely surrounded by hills and mountains varying in height above the valley floor from a few hundred feet on the east side to from 3,600 to 5,600 feet on the west side of the valley.

Baker City is located in latitude 44° 45′ north and longitude 117° 50′ west. From Baker City the valley takes a course a little west of north, with the East Fork of Powder River flowing longitudinally through it, the drainage being toward the north.

The area surveyed varies in width from about 5 miles at Haines to approximately 12 miles at a point 4 miles north of Baker City. It contains about 158 square miles, or 101,120 acres. This can be considered the maximum area of irrigable land between Baker City and Wolf Creek.

HISTORY OF SETTLEMENT AND AGRICULTURAL DEVELOPMENT.

In the early fifties, after the first gold excitement in California had partially subsided, a number of people came from that country to the Blue Mountains and started the town of Sumpter. Baker City was settled by people from Sumpter about 1863 or 1864. The first attempt at farming was made near what is now called Pocahontas, about 6 miles north of Baker City. For a few years farming was carried on in a desultory way, mining proving a greater attraction than farming. Since that time agriculture has gradually developed, but at no time has there been any rapid increase, and at present only about 44 per cent of the irrigable lands in the county are under cultivation. It is not uncommon to find farmers in the valley letting their farms lie idle while the owners go prospecting for the precious metals.

Stock raising has been one of the principal pursuits in the county, and within the last few years sheep raising has become a very important industry, causing, as is usual in such cases, considerable friction between the cattlemen and sheep men over the rights to the grazing range.

CLIMATE.

The climate of Baker Valley, from an agricultural standpoint, is arid. While the normal rainfall is comparatively high for an arid region, it will be noticed by the accompanying table of Weather Bureau records that very little rain falls during the summer months. The months of May and June receive as much rain as any, but the spring season being late the May and June rains are of little importance so far as crops are concerned.

The records of relative humidity show dry summer months. The average only is given, but during the afternoons in the summer the relative humidity commonly falls to 15 or 20 per cent. In the mornings it is usually quite high.

The date of occurrence of the last killing frost in the spring is very irregular, varying for the past fourteen years from February to the middle of June. In eight years out of the fourteen the last killing frost came between May 30 and June 17, while in a number of other years it came late enough to be injurious to fruit in exposed localities. The first frost in the fall is quite regular in occurrence, varying between September 4 and October 6, with the exception of 1901, when the first frost came on October 30.

The average wind velocity, as shown by records at Baker City, is

not high, the season of strongest winds being from February to May, inclusive. The maximum movement often reaches 30 to 35 miles per hour, and records of 50 miles per hour have been obtained, but such velocities are unusual. As the strongest winds occur from February to May, the crops raised in the valley are not sufficiently advanced to be injured seriously by them.

Undoubtedly the wind movement is stronger at Baker City than farther down the valley, as the town is located in the extreme end of the valley, near a canyon where the winds seem to concentrate.

The maximum temperature rarely exceeds 98 degrees, and the minimum seldom drops below zero.

Normal monthly and annual temperature, precipitation, and relative humidity.

Month.	Baker City.			Lagrande.	
	Temperature.	Precipitation.	Relative humidity.	Temperature.	Precipitation.
	°F.	*Inches.*	*P. ct.*	*°F.*	*Inches.*
January	25.2	1.50	75.2	33.3	2.33
February	27.9	1.44	72.6	31.3	1.97
March	35.5	1.42	65.6	41.3	1.75
April	44.7	1.06	56.6	48.2	1.87
May	52.0	1.90	58.8	54.4	2.21
June	58.0	1.27	54.6	59.7	1.46
July	64.4	.51	43.7	69.6	.62
August	66.4	.37	44.8	68.8	.45
September	56.6	.74	57.3	59.6	.85
October	47.3	.87	59.6	49.3	1.85
November	36.2	1.16	69.6	41.1	1.99
December	28.0	1.55	74.8	31.3	1.95
Year	45.4	13.79	61.1	49.0	19.30

PHYSIOGRAPHY AND GEOLOGY.

Baker Valley is completely surrounded by mountains. On the north and northeast are the Powder River systems, on the west the Blue Mountains, and on the south and southeast are spurs of the Blue Mountains and the Seven Devils Mountains. The mountains on the west rise abruptly to an altitude of from 7,000 to 9,000 feet above sea level, while the altitude of the valley is from 3,300 to 3,400 feet. The low mountains on the east side of the valley reach an altitude of about 4,000 feet.

The East Fork of Powder River flows longitudinally through the valley, following the eastern side. This river forms the chief drainage channel of the area, but its drainage area is not large, as the watershed of the Blue Mountains is but a comparatively short distance west of the valley. West of this the John Day River forms the drainage. The East Fork of Powder River as it flows through Baker Valley is fed by numerous smaller creeks, perennial and intermittent, from the Blue Mountains. No drainage reaches the river from the hills on

the east. Just north of the town of North Powder the East Fork of Powder River joins the North Fork of Powder River, and at this point the combined streams make a sharp turn southeast and flow into Snake River. The fall of the East Fork of Powder River through Baker Valley is gradual, being about 100 feet between Baker City and North Powder, or a fall of about 5 feet to the mile.

The Blue Mountains are the oldest of the ranges surrounding the valley. They formed, according to Professor Condon, an island during Cretaceous, or probably pre-Cretaceous, time. The rocks are composed chiefly of granite—apparently a soda-lime feldspar variety—quartzite, mica schist, and basaltic intrusions. Granite forms the greater part of the rocks exposed, both at the base and on the summit, the latter being in many places solid granite intersected with orthoclase veins. The lower hills on the east side are chiefly granite capped with basalt, the latter often occurring as intrusions near the base. The granite has been the chief source of the soils formed in situ. The same soil as that which occurs in the valley was found near the summit of the highest peaks of the Blue Mountains.

That the valley was formerly occupied by a lake is evidenced by the stratified material exposed in a number of places in cuts in the surrounding foothills, especially just north of Baker City. The material consists of compact clay and lime hardpan compressed into soft shale. This is underlain with alternating layers of fine sandy loam and volcanic ash, which in turn overlie a thick stratum of sand. The whole is distinctly stratified and contains no gravel. Furthermore, well-rounded cobblestones are numerous on the tops of the foothills in the south end and east side of the valley. Beds of volcanic ash were found in the canyons overlying typical muck, telling of vegetable growth suddenly cut short by showers of the ash, and of considerable disturbance of the earth's crust since the swamp or semiswamp conditions giving rise to the muck existed.

Evidently during the later period of the elevation, when the drainage system became fairly well established, the soils in the valley previously deposited in the lake were mostly washed away, as in no place in the valley proper are the soils deep, while they are everywhere underlain by coarse, well-rounded gravel. No evidence of stratification of the soils in the valley was found.

There is evidence that the soils in the central part of the valley have been brought there from the mountains by the streams, and supplemented by washing from the foothills, while the soils along and just below the foothills are colluvial in origin.

SOILS.

Five types of soil, exclusive of rock outcrop, were recognized and mapped in the area surveyed. The names and the actual and relative areas of these are shown in the table on the following page.

Areas of different soils.

Soil.	Acres.	Per cent.
Maricopa sandy loam	30,784	30.3
Yakima loam	29,760	29.4
Maricopa gravelly loam	17,216	17.0
Muck	12,352	12.3
Yakima sandy loam	10,816	10.7
Rock outcrop	192	.3
Total	101,120	

YAKIMA LOAM.

The Yakima loam has been encountered both in Washington and Idaho. In the Baker City area it consists of about 12 inches of heavy brown to black fine sandy loam or fine loam, underlain to a depth of 3 feet with brown or gray fine loam increasing in clay content downward. This is underlain to a depth of 6 feet with gray or yellow loam, usually gritty from admixture of sand, rarely grading into clay loam at a depth of 6 feet. In a few areas the brown or black fine loam extends to a depth of 6 feet without change. The whole type is underlain with waterworn gravel at a depth of from 3 to 6 feet. Volcanic ash is often found at a depth of from 3 to 6 feet, occurring only in local beds or lenses.

This soil type is located in the lower lying areas in the central part of the valley and along the creek channels. There are only a few small areas which contain an injurious amount of alkali, the average of the first 6 feet being considered. As the underground water map shows, most of this type has standing water at from 3 to 6 feet below the surface, and as the gravel stratum underlies the type at from 3 to 6 feet there can be but small chance for the accumulation of harmful amounts of alkali in the subsoil. On the other hand, the surface foot often contains injurious amounts of alkali, the principal components of which are alkaline carbonates, or black alkali. This is often found as a white incrustation on the surface, and is therefore mistaken for white alkali.

The principal crops grown on the Yakima loam are hay—consisting chiefly of wild meadow grasses, alfalfa, timothy and clover—oats, barley, and wheat, though the cereals do not constitute important crops on this type. The soil is in general adapted to these crops, but grain growing should not be generally practiced, as the best crop for the type is hay. Many of the areas now in grain should be seeded to tame grasses. The quality of hay commonly grown on the type could be much improved.

The table following gives mechanical analyses of typical samples of this soil.

Mechanical analyses of Yakima loam.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
8861	$\frac{1}{8}$ mile SW. of E. cen. sec. 35, T. 6 S., R. 39 E.	Fine sandy loam, 0 to 12 inches.	1.73	0.10	1.12	1.24	9.08	15.88	55.64	16.94
8858	Cen. SW. $\frac{1}{4}$, sec. 11, T. 8 S., R. 39 E.	Loam, 0 to 12 inches.	1.63	1.32	7.54	4.68	11.26	13.82	42.30	18.96
8859	Subsoil of 8858......	Loam, 24 to 36 inches	.64	1.80	6.30	5.70	12.56	11.90	43.10	18.54
8862	Subsoil of 8861......	Loam, 24 to 36 inches	.72	.30	3.56	3.34	12.72	13.80	42.02	23.90

The following samples contained more than one-half per cent of calcium carbonate ($CaCO_3$): No. 8861, 2.60 per cent; No. 8858, 8.20 per cent; No. 8859, 10.80 per cent; No. 8862, 1.80 per cent.

MUCK.

The surface soil of the Muck consists of 2 or 3 feet of brown or black mucky loam. The color of the material becomes grayish in the subsoil. The deeper subsoil consists of sand, usually quite coarse in texture. In some areas the surface soil is underlain by a green or yellow clay loam or clay, extending to a depth of 3 or 4 feet, and resting on gravel.

This type occupies low-lying areas in the central part of the valley and along the streams. It is generally poorly drained, standing water being found at the time of the survey within from 1 foot to 3 feet of the surface. This poor drainage is the result of the many sloughs used for irrigation which traverse the meadow lands, as well as a consequence of excessive irrigation on the higher lying lands. Not infrequently a stream is turned into these meadows in the spring and allowed to run continuously for several weeks at a time, the whole area being covered with water from a few inches to 2 or 3 feet deep. Though low and wet, the type is free from alkali.

Hay, chiefly wild, is the principal crop grown on this soil type at present. With drainage and seeding to tame grass, the quality of this product could be much improved.

YAKIMA SANDY LOAM.

The Yakima sandy loam consists of from 2 to 4 feet of gray or yellow fine sandy loam, becoming heavier in texture in the subsoil and often grading into a silty loam. This is underlain to a depth of 6 feet with yellow loam or fine loam, rarely becoming clay loam in the sixth foot. In the areas mapped as Yakima sandy loam in the southern part of the area gravel underlies the soil at a depth of from 4 to 6 feet.

The type is located in the southern and southeastern parts of the valley, between the gravelly loam near the foothills and the lower

lying areas of Yakima loam. The texture of the Yakima sandy loam is intermediate between that of the interstitial soil of the Maricopa gravelly loam and that of Yakima loam. The areas of the Yakima sandy loam are practically level, the slope being in general not greater than that of the valley.

The Yakima sandy loam is at present well drained, owing to its relatively high position and to the fact that the level and lower lying areas of the type in the southern part of the area have not yet been cultivated and subjected to excessive irrigation. In these lower areas, however, the underground water is within 5 or 6 feet of the surface, and irrigation there, unless great care be taken, will soon cause trouble by raising the subsoil water, which, by evaporation at the surface, will form alkaline carbonates. As this area is underlain with gravel at a depth of 5 or 6 feet it could easily be kept well drained and free from alkali.

The Yakima sandy loam is colluvial in origin, the soil having been formed by transportation of material from the hills at the south end of the valley. This soil was either deposited during the lake period of the valley, or has been formed from the decomposition of basalt and granite, the latter being the case in the southern part of the area of this type.

With the exception of small areas in the central part of the valley, there are at present but small amounts of alkali in this type. Neither are there large areas of black alkali in this soil at present. Care should be exercised in the irrigation of the new land just being brought under cultivation a few miles north of Baker City, below Baldock Slough.

The crops grown on this type consist of wheat, oats, barley, and some timothy and clover. Most of the type is adapted to any crop suited to the climate of the area.

The following table gives mechanical analyses of typical samples of this soil type.

Mechanical analyses of Yakima sandy loam.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
8865	S. cen. sec. 8, T. 9 S., R. 40 E.	Fine sandy loam, 0 to 12 inches.	1.97	0.50	3.34	3.02	14.10	15.42	51.92	11.54
8867	½ S. of NE. cor. sec. 13, T. 8 S., R. 39 E.	Fine sandy loam, 0 to 12 inches.	.87	2.10	5.58	3.76	14.88	20.56	40.32	12.26
8866	Subsoil of 8865......	Fine sandy loam, 24 to 36 inches.	1.48	.54	2.30	2.70	15.20	15.60	54.04	9.58

The following sample contained more than one-half per cent of calcium carbonate ($CaCO_3$): No. 8867, 1.40 per cent.

MARICOPA SANDY LOAM.

The Maricopa sandy loam consists of from 18 to 24 inches of fine sandy loam or light loam, underlain to a depth of about 4 feet with a gritty and very compact heavy loam or clay loam, the soil grains of which are partially cemented with calcium carbonate, though in this part of the soil section no true hardpan occurs. Below 4 feet the texture becomes lighter and the soil often contains small fragments of rock cemented by calcium carbonate into a hardpan. Often the hardpan does not occur until a depth of 6 feet is reached, in which case it directly overlies the subsoil water. Angular or subangular gravel is usually found at a depth of from 4 to 10 feet, though in a few instances this is not found even at a depth of 30 feet.

A phase of the Maricopa sandy loam has a shallower surface soil, ranging from a few inches to 12 inches in depth. The soil contains more coarse sand than in typical areas, and the underlying yellow, sticky, gritty loam or clay is found at a depth of 3 feet. This phase is located in the southeastern part of the valley, directly under the foothills. The southern part of the area is level, but the remainder has a slope of a few degrees, and could be easily cultivated. Though irrigable, it is as yet entirely uncultivated. Being the highest land in the southern part of the valley, it is at present well drained, and would not present any difficult problem in drainage if irrigated. In the southern part of the area of this phase more alkali occurs in the first 6 feet of soil than is found in any other part of the valley, though the surface foot contains less than 0.20 per cent of salt.

The more typical area of this soil lies in the northern part of the valley, beginning just north of Hutchinson Spur and extending across the entire width of the valley.

This type has a greater slope than any other soil in the area, but the slope does not exceed 5 degrees. A mesa extending from North Powder to the Blue Mountains has been cut by North Powder River and Wolf Creek into bluffs varying in height from a few feet at North Powder to about 75 feet at the western limit of the survey. This mesa varies in width from a fraction of a mile near North Powder to 2½ miles at the western limit of the area. This area is also broken in the northern part of T. 7 S., R. 39 E. by a granitic hill which attains an altitude of about 300 feet above the valley. The surface for 2 or 3 miles north, south, and west of Hutchinson Spur is level.

Owing to the slope of the surface and to the underlying gravel and conglomerate the drainage of this soil is good.

The Maricopa sandy loam owes its origin to the decomposition of biotite granite, the feldspar of which is principally the soda-lime or lime-soda variety. Some of the soil has been formed in situ, but most of it is colluvial, having been transported either from the base of the Blue Mountains or from the granitic hill above mentioned.

This type is generally free from harmful accumulations of alkali, though small areas of alkali occur below the small benches or mesas in the northern part of the area of the type, the chief components being alkaline carbonates. The subsoil of this soil usually contains considerable lime.

Most of the Maricopa sandy loam is not yet under cultivation. This is due in part to scarcity of water, but largely to the location of the soil, making necessary a more extensive canal system than has yet been constructed in the valley.

The crops grown on the cultivated areas consist of clover, timothy, alfalfa, and the cereals, but the soil is adapted to any of the crops suitable to the climate. The upper areas, on the western side of the valley, are especially well adapted to hardy fruits, such as late blooming pears and apples.

The following table gives mechanical analyses of typical samples of this soil type:

Mechanical analyses of Maricopa sandy loam.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
8852	¼ E. of W. cen. sec. 8, T. 8 S., R. 39 E.	Fine sandy loam, 0 to 12 inches.	2.67	1.14	3.12	2.62	13.48	18.38	52.52	8.72
8854	NW. cor. sec. 26, T. 7 S., R. 38 E.	Fine sandy loam, 0 to 12 inches.	3.16	2.84	5.80	3.26	13.06	18.80	44.26	11.86
8850	¼ S. of cen. sec. 32, T. 7 S., R. 40 E.	Light clay loam, 0 to 12 inches.	.61	1.40	3.70	2.70	9.88	14.38	52.94	14.18
8853	Subsoil of 8852......	Fine sandy loam, 12 to 24 inches.	.32	2.36	5.72	4.04	17.32	19.50	40.18	10.46
8855	Subsoil of 8854......	Loam, 24 to 36 inches.	.81	4.66	8.30	5.06	13.92	14.14	38.34	14.70
8851	Subsoil of 8850......	Loam, 12 to 24 inches.	.16	5.84	10.84	5.54	12.50	9.94	35.82	19.68

The following sample contained more than one-half per cent of calcium carbonate ($CaCO_3$): No. 8851, 2.60 per cent.

MARICOPA GRAVELLY LOAM.

The Maricopa gravelly loam consists of a sandy loam or fine sandy loam from a few inches to 18 or 24 inches deep, underlain with gravel, bowlders, or conglomerate. The surface soil contains gravel varying in size from fine particles to fragments 2 or 3 inches in diameter. The amount of gravel in the surface varies from a trace to as much as 50 or 60 per cent, and in the intermittent creek channels—which are often quite wide—bowlders with very little interstitial soil are found.

The type is found on the slopes next to the mountains in the south-

western part of the area and in the lower areas in the southern end of the valley. These latter areas were formerly creek channels, which have since been partially or completely filled with colluvial soil from the hills.

The foothill areas of the type have a slope of a few degrees and are easily tilled. The lower lying areas in the southern part of the sheet are level.

The areas of Maricopa gravelly loam, with a few exceptions, are well drained and free from alkali, though the surface foot of the lower areas sometimes contains injurious amounts of alkaline carbonates.

The crops raised on this soil are wheat, oats, barley, clover, and alfalfa. Excepting the most gravelly areas, the type is well adapted to alfafa, though this land will require more frequent irrigation than the lower lying Yakima loam.

WATER SUPPLY AND IRRIGATION.

Owing to the fact that agriculture was first undertaken merely to supply food for the mining population, the first attempts at irrigation were very crude, consisting in each farmer making his own ditch and filing on what water he wanted from the creek, and thus no effort was made to obtain a comprehensive canal system. As the industry had a very gradual growth, there being no very rapid increase at any one time, the same method of individual ditch making continued, and consequently the area is to-day without a proper system for distributing the irrigation water. Often the individual claim for water would amount to more than the normal flow of the particular creek on which the filing was made. As a result claims have been filed on many times more water than the creeks supply.

Until within the last few years there has been little contention among the farmers over the water supply, as the principal crop grown has been meadow hay, and the owners simply turned a creek, or part of one, on their meadows in the spring when the water was high, and paid little attention to it until time to turn it off in the summer. Of late years, however, large tracts of the higher lying lands have been brought under cultivation, and the grain farmers are finding themselves in need of more water.

No data could be obtained on the discharge of the river or of any of the creeks, as no measurements have been made. It is claimed by some of the ditch builders that 1 miners' inch of water is necessary for 1 acre of land, or about 1 second-foot for every 40 acres. This is undoubtedly more water than is necessary for most of the soils, especially for the Yakima loam and the Maricopa sandy loam, with their heavy subsoils, which will hold water a long time. The Maricopa gravelly loam will require considerable water. There can be no question that the above-mentioned estimate is altogether too

low for the large areas of meadow lands in the central part of the valley. If this—1 second-foot per 40 acres—were the maximum amount required, the combined flow of the river and all the creeks would have to be about 2,500 second-feet in order to water all the irrigable land—approximately 101,120 acres—in the valley. The river and creeks will probably not discharge this amount of water, certainly not during the summer months. If the amount required is put at one-half that mentioned, or 1 second-foot per 80 acres, which would undoubtedly be too much for the whole valley, the discharge of the streams would have to be 1,250 second-feet.

These figures are based on the assumption that all the land between Baker City and Wolf Creek, from one side of the valley to the other, is to be irrigated. Only 27 per cent of all the farming land in the county is now under irrigation, and probably not more than 40 or 50 per cent of the land in Baker Valley is under irrigation. About 60 per cent of the land in the valley does not need any, or at least very little irrigation after July 1. The only crop which needs water after that time is alfalfa, and the acreage devoted to this crop forms but a small percentage of the cultivated area. It would thus seem that there is plenty of water for all present purposes.

There has been some talk of making a reservoir south of Baker City to store water for use in the summer. The plans heretofore considered are of doubtful value, and it would be much better properly to handle and distribute the present water supply than to go to any great expense to construct reservoirs for storage, unless upon some better plan than any so far proposed.

The present irrigation system of the valley uses much more than the necessary amount of water, as each farmer has his own little ditch which he uses for his principal distributing channel. In this way he simply helps himself to the amount of water to which he thinks himself entitled, which is usually all he can get.

A good canal system would result not only in a great saving of water, but would also greatly improve the seepage water and alkali conditions. By having a general distributing system there would be less loss by seepage, and all the little private ditches, instead of carrying a constant supply of water, whether it is used or not, would be filled only when the particular field to be supplied was irrigated. This would prevent the loss of water to one farmer through the excessive use of it by another.

During the last two or three years Baldock Slough has been used as a canal to irrigate the land near it, which has recently been brought under cultivation. While this is probably the best the farmers can do at present, the practice is certainly a bad one. The slough, having been formed by the drainage from that part of the valley, is low and should be used as a drainage channel rather than as a canal. In order

to get water from this slough onto the surrounding land it is necessary to back the water up to the level of the land for some distance, and as the land lying under it is very level and subirrigates to a great extent, this results in filling up the subsoil with water. In most of the areas where black alkali exists it has been formed by such methods of irrigation, the subsoil water soon reaching the surface, there evaporating, and forming black alkali from the bicarbonate which it holds in solution.

The irrigation practice in the area consists in conducting the water onto the land by means of ditches and letting it spread over the surface. If the ground is quite level and there is no trouble from alkali, this method will do very well. It is the only method that can be economically used on the meadow lands. On many of the grain areas, where the ground is not level, the check system could be advantageously used. By that method the entire surface would be covered and the alkali spots on the higher parts of the fields would disappear.

As will be seen from the following analyses, the irrigation water used is of good quality:

Analyses of spring and river waters.

[In parts per 100,000.]

Constituent.	Hot Springs, N. C., sec. 25, T. 6 S., R. 39 E.	Powder River, central sec. 25, T. 6 S., R. 39 E.	Powder River, 1 mile north of Baker City.
Ions:			
Calcium (Ca)	0.7	0.7	2.5
Magnesium (Mg)	2.1	1.1	2.2
Sodium (Na)	2.8	5.4	41.6
Potassium (K)	0.6	0.8	1.4
Sulphuric acid (SO_4)	3.3	1.7	95.2
Chlorine (Cl)	4.3	1.0	0.5
Bicarbonic acid (HCO_3)	3.0	16.6	7.2
Carbonic acid (CO_3)	3.4	1.4	1.1
Conventional combinations:			
Calcium sulphate ($CaSO_4$)	2.4	2.4	8.5
Magnesium sulphate ($MgSO_4$)	2.0	....	10.9
Sodium sulphate (Na_2SO_4)	....	....	116.6
Sodium carbonate (Na_2CO_3)	6.0	2.4	1.9
Sodium chloride (NaCl)	....	0.5	0.8
Sodium bicarbonate ($NaHCO_3$)	0.7	15.3	9.9
Potassium chloride (KCl)	1.1	1.5	....
Potassium sulphate (K_2SO_4)	....	....	3.1
Magnesium chloride ($MgCl_2$)	5.0	....	....
Magnesium bicarbonate ($Mg(HCO_3)_2$)	3.0	6.6	....
Total solids	20.2	28.7	151.7

ALKALI IN SOILS.

The method used in constructing the alkali maps accompanying this report was the usual one employed by the field men, viz, by determining the total amount of soluble salts at soil saturation in each foot section to a depth of 6 feet by means of the electrolytic bridge. The average of these six determinations was then mapped as the salt content of the soil to that depth. The alkaline carbonate, or black alkali map, was made directly from titrations made in the field, using an extract made by shaking up 12 cc. of saturated soil with 250 cc. of water and forcing the solution through a Pasteur filter. These titrations were always made immediately after the soil was shaken up with the water.

The chief constituent of the alkali in the cultivated valley soils is alkaline carbonate, or black alkali. The subsoil water carries bicarbonates in solution, and upon the water reaching the surface by capillarity it evaporates and leaves the salts behind. As evaporation proceeds the hydrogen carbonates, or bicarbonates, lose water and carbon dioxide, which changes the salts to the normal carbonate or black alkali. The subsoil also contains some alkaline carbonates; and the capillary attraction of these salts being much greater than that of any other constituent in the soil, there is a strong tendency for these to concentrate at the surface. The surface deposit of alkaline carbonates is thus due partly to its formation from the hydrogen carbonates and partly to the salts being brought up directly from the subsoil.

In the areas of Maricopa sandy loam in the southeastern part of the sheet the subsoil contains considerable alkali. The maximum salt content occurs in the third or fourth foot sections, and but very little, or less than 0.20 per cent, in the surface foot. The alkali here owes its origin to the decomposition of the rocks from which the soil has been derived, and is principally white alkali, though considerable alkaline carbonate also occurs. These latter salts have also been formed in place. There is a great deal of lime in the subsoil of this type, and the calcium and magnesium carbonates have been dissolved to a certain extent, resulting in the formation of the hydrogen carbonates of these bases. These hydrogen carbonates then react with the soluble sodium and potassium salts, such as chlorides and sulphates, which are present in considerable quantities, forming the hydrogen carbonates of sodium and potassium. These, upon reaching the surface, change to the normal carbonates by the loss of carbon-dioxide and water. Some alkaline carbonates are also formed in the subsoil, as these were found from 4 to 6 feet below the surface. The calcium and magnesium carbonates are soluble as such to some extent, especially in the presence of other salts in solution. These carbonates then react directly with the sodium and potassium salts, forming

soluble alkaline carbonates. But here, again, the strong capillary attraction of these salts causes them to be concentrated at or near the surface. In some cases as much black alkali was found in the second foot as in the surface foot.

In the areas of bad alkaline surface conditions the alkaline carbonates were always present in excess of any other single component of the soluble salts, with the exception of hydrogen carbonates, and these are in reality potential alkaline carbonates. In some of the determinations the percentage of alkaline carbonates exceeded that of the hydrogen carbonates. The former varied in quantity from 0.05 per cent to 1.53 per cent in the surface foot, with an average of about 0.15 per cent for the determinations made in the areas where it was necessary to map the black alkali. Sulphates were very often found, sometimes in large quantities, in the presence of the alkaline carbonates. Chlorides were nearly always present, but always in smaller quantities than the alkaline carbonates. The amount of hydrogen carbonates seldom exceeded that of the alkaline carbonates by more than two or three times.

In the Maricopa sandy loam, as before mentioned, the maximum salt content occurs in the subsoil at from 2 to 4 feet below the surface, while in the cultivated areas the maximum is in the surface foot. The highest percentage of alkali found in the surface foot was 2.10 per cent, but even in such cases the second foot section seldom contained as much as 0.40 per cent, and usually very much less.

Many small local spots of alkali occur in the area in otherwise good lands, but these are too small to be shown on a map of the scale used. Such spots are of frequent occurrence in the meadow land.

RECLAMATION OF ALKALI AND SWAMP LANDS.

Owing to the fact that in the cultivated areas the maximum salt content occurs usually in the surface foot, the problem of alkali reclamation is not as serious as it would be if the subsoil contained excessive amounts of alkali. The character of the prevailing alkali—alkaline carbonates or black alkali—makes it necessary to prevent the surface accumulation of alkali as far as possible. The black alkali in the cultivated areas owes its origin to the evaporation of the subsoil water at the surface. Were the water table kept far enough below the surface to check this capillary process it is evident that there would not be so much black alkali on the surface. The subsoil water should not be permitted to come nearer the surface than 6 feet. This can be accomplished by an economical use of water on the soils in which the underground water table is not yet too near the surface, or by underground drainage where the water table is already too high.

Many of the black alkali areas can be much improved by proper treatment without artificial drainage. The level alkaline areas of the

Yakima loam, where the growing of grain is attempted without success, could by a little care be made much more valuable than they are at present. In these areas—and in those in which the alkaline carbonates have accumulated to such an extent that nothing but salt grass will grow—the ground should be well plowed and thoroughly pulverized, so as to break up the compact surface soil caused by the puddling effect of alkaline carbonates. Then checks should be made—preferably not more than about 2 acres in size, unless the ground is very level—quickly filled with water, and immediately drained again. It will not do to let the water remain in the checks for any length of time, for that will aggravate the conditions by more thoroughly saturating the subsoil with water and raising the underground water table. Where the subsoil water is within capillary reach of the surface, which is usually the case wherever a surface crust of alkaline carbonates occurs, the salts will again come to the surface after the water has been drained off the checks. To prevent this the soil should be cultivated as soon as dry enough in order to break up the capillary spaces at the surface. By a few repetitions of these small but frequent irrigations and by careful cultivation to preserve a mulch, the soil would soon be in condition to grow crops.

This reclamation process could be carried on very advantageously during early spring, after the frost is out of the ground, so that when warm weather comes the seed bed would be in fairly good condition. The seed should not be sown until the ground and weather are both warm, and they should preferably be drilled in. After they have germinated the small and frequent irrigations should be continued, as otherwise capillarity would soon bring more alkali to the surface. This irrigating and draining off of the checks will finally either wash the alkaline carbonates out of the soil, or else change them to the less harmful bicarbonates. When the plants are high enough to shade the ground evaporation will be much diminished and less irrigation will be necessary. The plants will then resist more alkali than during the period of germination and early growth. If alfalfa is the crop sown, the warm weather will promote a rapid growth and the ground will soon be entirely shaded. Such grasses as timothy, red clover, white clover, rye grass, etc., would be excellent crops to grow on such areas.

Of course drainage ditches would hasten the process of reclamation, as the check water could be quickly and more completely drained away. More water could be advantageously used, as the drains would carry away the subsoil water. This method is to be preferred where practicable, but it is more expensive and probably will not be extensively used for some time to come in the area surveyed.

The areas of land in the valley with a heavy subsoil accumulation of alkali are small, the principal ones being found in the Maricopa sandy loam area in the southern end of the valley. This land is not yet culti-

vated, being above any present irrigation system. The subsoil here is heavy and the land will be difficult to drain.

The water conditions in the swamp lands and in the Muck have been caused by excessive irrigation. The water table in these areas is within 3 feet of the surface, and sometimes occurs at a less depth. No excessive amounts of alkali are found in these areas, as the amount of water used keeps it washed out. These areas do not, therefore, present a problem in alkali reclamation, but one of the removal of subsoil water.

No extensive drainage system is necessary or even desirable, as the cultivated grasses will do well with water within 4 feet of the surface, provided irrigation is carried on in such a way as to prevent accumulation of alkali at the surface. The water table is too high in these swamp and overflow areas to allow the growing of a good quality of grass.

The swamp areas and sloughs should be ditched to a depth of about 5 feet, which would reach the underlying sand and gravel, and this alone would greatly improve conditions. Water should then be applied in small amounts and only when necessary. It should not be turned on and allowed to run for several weeks at a time. The excessive amount of water used on the meadows in spring, when the soil is cold and the weather anything but mild, checks the growth of the grasses.

By draining the swamps, and by practicing economy in the use of water, better grasses could be introduced. Timothy, red clover, white clover, rye grass, vetch, etc., were all found doing well in a few fields where conditions were fairly good. These cultivated grasses would give heavier yields per acre, and the quality of the hay would be vastly superior to that now produced. As the principal industry of the valley is the production of hay and stock feeding, it would be well worth while to improve the grasses. No large areas of black alkali occur in the meadow land, but where small areas do occur timothy will be found more resistant than any of the other tame grasses.

RESISTANCE OF CROPS TO BLACK ALKALI.

An attempt was made to obtain some information as to the resistance of different crops to alkaline carbonates. This would perhaps not be a very difficult problem could all the factors influencing the alkali conditions be kept under control. The conditions in the field, however, are always changing. The alkaline carbonates being readily soluble, every rain and every irrigation changes the concentration of the salts in the surface foot of soil. Again, when a long dry period occurs and the temperature is high, evaporation is greatly increased, more subsoil water is brought to the surface, and the amount of the carbonates is considerably increased. Under such varying conditions

one does not know whether a particular test in an alkali field represents the limit for that crop. In the spring the surface soil may be sufficiently free from alkaline carbonates to permit of good germination and a comparatively good growth of the plant, and later in the season the crop may be killed by an increased concentration of the salts.

The following table exhibits the results obtained where the conditions appeared to have been comparatively constant, both in regard to crops and alkali content. The borings were made at the root crowns of the plants.

Tests for resistance of crops to alkaline carbonates.

Boring No.	Crop.	Condition of crop.	Alkaline carbonates.	Chlorides.	Sulphates.
			Per cent.	*Per cent.*	
54	Oats	Poor; hardly worth cutting	0.065	None.	None.
78	do	Good	.03	0.055	Trace.
96	do	Dead	.05	.04	None.
97	do	Dying, after growing about 8 inches.	.04	.07	Heavy precipitate.
97	None	(Second foot of soil)	.03	None.	Light precipitate.
102	Oats	Growing fairly well, but in chlorose condition.	.03	None.	None.
105	do	Same condition as No. 102	.05	None.	Do.
186	do	12 inches high, but not good crop.	.05	.225	
185	do	2 to 3 feet high, well headed out.	.08	None.	None.
138	Wheat	Fairly good; will make average crop.	.035	None.	Do.
141	do	Entirely bare ground; surrounding wheat 3 feet high.	.065	.16	Moderate precipitate.
142	do	Good; 2 feet high and fully headed out.	.04	Tr.	None.
153	do	Fair; plant 18 inches high, but not profitable crop.	.05	.16	Heavy trace.
136	Timothy	Good, but only average crop; not heavy.	.07	None.	Not tested.
166	Barley	Matured, but plants stunted, and poor stand.	.05	.025	Moderate precipitate.
182	Alfalfa	Chlorose, but growing fairly well; second crop.	.08	None.	None.
183	do	Good; fair stand; second crop, 8 to 10 inches.	.08	None.	Do.
184	do	Good; best that could be found in field.	.03	None.	Do.

It will be noticed that the presence of sulphates has considerable influence on the plants, since they apparently would not stand as much of the alkaline carbonates when the sulphates were absent. It is probable that some of the sulphate was magnesium, a salt which has as deleterious an effect on plants as the alkaline carbonates. It has been shown [a] that magnesium sulphate is not effective in neutralizing the toxic effect of sodium carbonate when germinating seeds of lupine and alfalfa. The same report also shows magnesium sulphate to be more toxic in pure solution than sodium carbonate.

[a] Report 71, U. S. Dept. of Agri.

It is very likely that in the field determinations tabulated above the effect of the alkaline carbonates on the plants, for which limits of resistance were sought, was modified to a large extent by the presence of magnesium sulphates. The chlorides would undoubtedly have a somewhat similar effect, though to a less extent. Unfortunately, the sulphates could not be determined quantitatively in the field, no suitable field method having been devised for this.

It seems that oats in the presence of alkaline carbonates, alone, will stand more than is generally supposed, that is, 0.05 per cent, as the table shows this crop doing well in soil containing 0.08 per cent. Wheat does not seem to be able to stand as much as oats.

The alfalfa and timothy fields tested for limits of alkaline carbonates were old fields and had been giving good yields. The timothy was nearly matured, while the alfalfa field had been cut once, and the second crop had made a growth of 8 or 10 inches and was in good condition.

AGRICULTURAL CONDITIONS.

The most important industry in the county is mining. Stock raising is next in importance, and lately sheep raising has become prominent. Last of all in importance comes agriculture. General farming, such as the growing of grain, corn, vegetables, fruits, etc., has not been considered of much importance, though in recent years more land has been added to the grain areas by bringing new lands into cultivation. The cultivation of cereals should not generally be undertaken.

Most of the cattle range in the mountains during the late spring, summer, and fall months. Late in the fall they are brought down to the valley and pastured on the grain and hay stubble fields and fed from the straw stacks until about the first of January. They are then fed hay until the middle or last of April, when they are again driven to the mountains and hills. About 1 ton of hay is allowed for each animal during the winter feeding. Very seldom are sheds or other shelter provided for the cattle, as the winters are not severe and the snowfall is often very light.

The owners of large herds of cattle or sheep generally have large hay ranches, and many of the small farmers sell their hay to the ranchmen. There is a tendency among the farmers to grow hay for the purpose of selling, rather than to feed their own cattle or sheep, often to the detriment of their stock. In most cases it would pay better to feed the hay than to sell it.

Many smaller herds of cattle, especially of the finer breeds, of which the Herefords are the most important, are pastured in the valley during the summer. In this way they are kept in good condition, and profitable use is made of the salt grass and foxtail meadows, which

afford excellent grazing but are of small value for hay. It is only recently that any but the most common breeds of cattle have been raised.

There are excellent opportunities for the development of the dairy industry in the valley. This industry is only carried on to a small extent at present. It would certainly appear, in view of the ready market and the good prices for dairy products, that it would pay to introduce a good dairy breed, such as the Holstein, and develop the industry on a larger scale.

According to the Twelfth Census the average value per farm of live stock in Baker County in 1900 was $1,932, or for the entire county $1,400,712, placing the county eighth in the State in this industry.

The principal grain farming in the area is carried on by the later settlers, the older ones confining themselves chiefly to the production of hay. The land acquired by the later settlers is usually new and uncultivated, and grain crops are better suited to this kind of land at first, or until it is thoroughly broken up and leveled. The new settlers, however, gradually go into the production of hay.

The prosperity of the farming and stock-raising class is due to the natural conditions surrounding them. Usually the farmers own and operate their farms, and this is especially true of the smaller holdings. The larger land owners, who are also generally interested in stock, often have their hay ranches superintended by a manager.

The total number of acres in farms in Baker County, as reported by the Twelfth Census, was 176,455, of which 78,389 acres were reported improved, or about 44 per cent of the entire area of farming land. According to the same authority, only 46,674 acres were irrigated. This would be less than 27 per cent of the total farming land, or a little less than 60 per cent of the improved area. The average size of farms in Baker County in 1900 was 243 acres, of which 108 acres were improved.

Considerable labor is hired by the farmers during the haying season but at other times the labor item is not large, except in the case of stockmen. The average cost of labor per farm in 1900 was $220. As most of the smaller farmers do their own work, or cooperate with their neighbors, the cost of labor on the larger ranches is considerably more than the figure given. About $2.50 per day with board is paid for labor during the haying season. Machinery is quite extensively used in handling the hay.

The value of all crops raised in Baker County in 1900 was $537,563. The hay and forage crops alone were valued at $329,941, or 61 per cent of the value of all crops. Owing to the inferior character of much of the hay produced the percentage of land devoted to hay and forage crops would be greater than 61 per cent. The value of the

cereals was placed at $162,188, or a little over 30 per cent of the entire value of all crops. Vegetables and orchard fruits come next in order of importance.

The chief hay-producing grasses on the meadows in the valley consist of several species of Juncus, Scirpus, Carex, and Eleocharis, and of foxtail and various kinds of salt grasses, all of which are rather poor in quality and should be replaced by more succulent grasses. One ton of hay per acre is a good average yield for these grasses.

Timothy, redtop, and the clovers, especially *T. spinulosum*, *T. repens*, *T. harveyensis*, and *T. variegatum*, are found to do very well. Wherever these grasses have been given a fair opportunity they have developed a heavy growth, far exceeding that of the swamp grasses.

The price of hay depends largely upon the character of the winter season. Four or five dollars a ton is a common price for the better kind of wild hay. Alfalfa yields two cuttings, and the fields usually afford pasturage after the second crop is removed. Four to 5 tons per acre is the usual annual yield for this crop, and the hay sells for $2 or $3 a ton more than wild hay. Timothy and clover will average 2 tons per acre, and some fields were seen which yielded from 3 to 4 tons. This crop is usually valued at from $2 to $4 a ton more than alfalfa. Oats and barley will average about 35 to 50 bushels per acre, though much larger yields have been obtained in a number of cases.

Generally speaking, the crops grown are adapted to the soils, though as the region is essentially a stock-raising country much land now devoted to grain could be more profitably planted to cultivated grasses. Especially is this true of the alkali areas where the production of grain is attempted.

The area has good shipping facilities, the main line of the Oregon Railroad and Navigation Company traversing the valley and affording connection with all lines east. The principal shipping point to the west is Portland. The Sumpter Valley Railroad furnishes transportation to Sumpter and Whitney, the chief mining camps west of Baker City. The surrounding mining camps consume a considerable proportion of the general farm products of the area. The principal market for hay is at home, the stockmen taking most of it. A small amount is baled and shipped out of the area.

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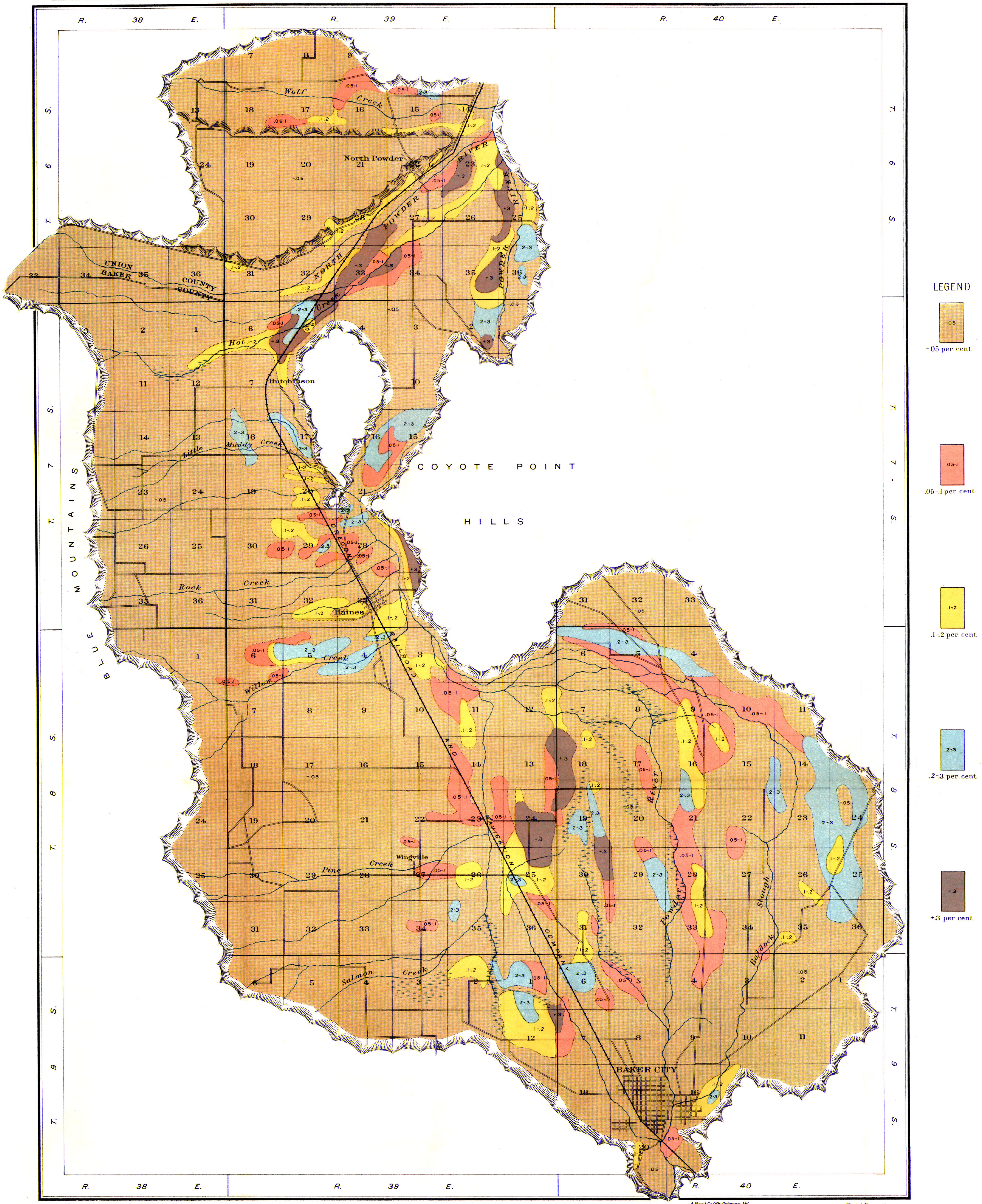
BLACK ALKALI MAP

OREGON
BAKER CITY SHEET



Black Alkali surveyed by
Chas. A. Jensen and W. W. Mackie
1903.

Scale 1 inch = 1 mile

Field Operations
Bureau of Soils
1903.

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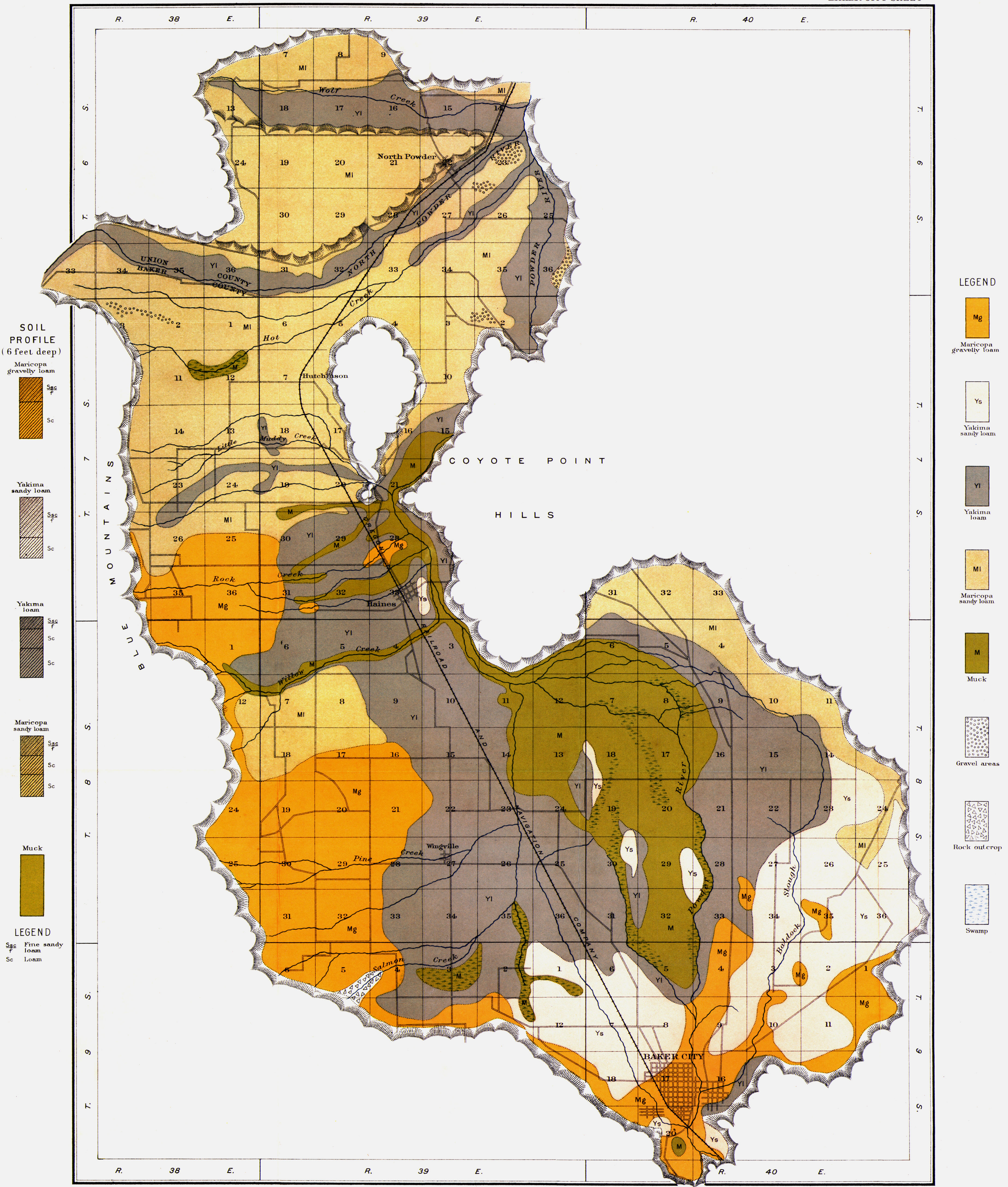
SOIL MAP

OREGON
BAKER CITY SHEET



Soils surveyed by
Chas. A. Jensen and W. W. Mackie
1903.

A. Hoen & Co. Lith. Baltimore, Md.

Scale 1 inch = 1 mile

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1903.

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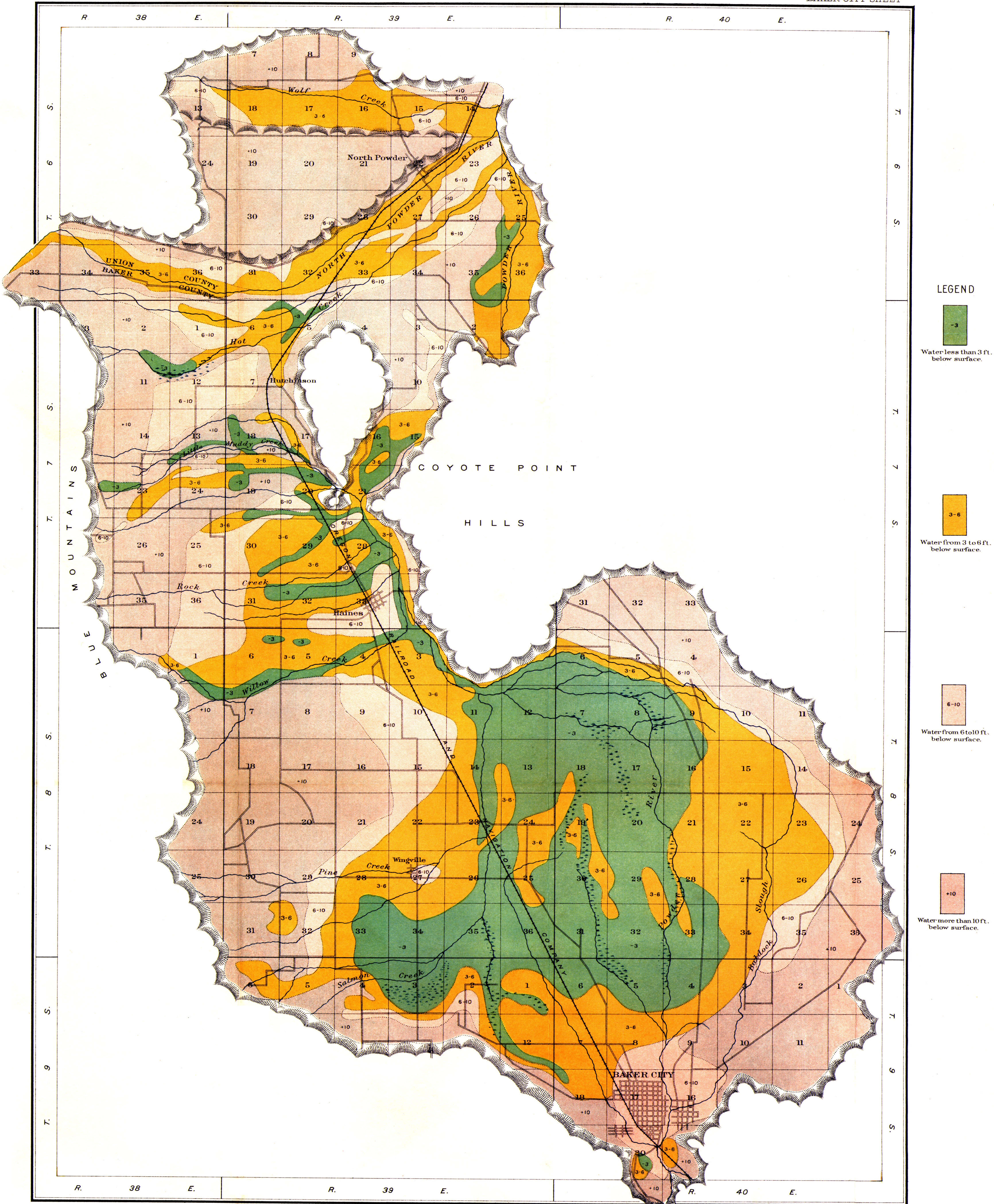
UNDERGROUND WATER MAP

OREGON
BAKER CITY SHEET



Water surveyed by
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1903.

0 1 2 3
Scale 1 inch = 1 mile

A. Hoen & Co. Lith. Baltimore, Md.

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